Review Article

How is Bangladesh growing more susceptible to infectious disease epidemics as a result of climate change? A review of the knowledge gap and suggested future steps

Abstract

Bangladesh is facing unpredictable weather patterns, as well as a consistent rise in temperature and precipitation. Climate change has had a negative impact on physical and mental health, leading to an increase mostly in prevalence and variation of infectious diseases, as well as psychological issues such as depression and anxiety disorders. Given the country's inherent sensitivity to climatic influences, the climate-health nexus is a relatively unexplored subject of research. The purpose of this article is to investigate the severity of climate change in Bangladesh and how it impacts health of the public. Morbidity and mortality due to heat stress, cyclones, floods, droughts, and other weather extremes at various spatiotemporal scales have been observed as direct effects of climate change in Bangladesh. The indirect effects involve more complicated paths, such as affecting food and water security due to salinity intrusion and the development of infectious diseases because of shifts in vector and pathogen ecology. To mitigate the effects of climate change on various infectious diseases, healthcare and response systems must be strengthened. By implementing proactive adaptation methods, we may significantly and actively contribute to preventing and regulating the negative consequences of climate change on human health. There is little evidence to make sound health policy decisions in the context of climate change, and there is a lack of multidisciplinary research activities. Despite these constraints, gathering and reporting scientific information is essential for developing a resilient health system in climate-vulnerable countries like Bangladesh and other low-income regions.

Keywords: Climate Change, Emerging Infectious Disease, Human health, Bangladesh.

Introduction

Climate change has been one of the most important challenges and one of the most serious threats to human health and well-being (Bing Xu et al. 2016). The Lancet Commission and the World Health Organization (WHO) have pronounced climate change to be "The greatest global health danger of the twenty-first century" (Costello et al. 2009; Rahman et al. 2019; Watts et al. 2017). The study of the relationship between the environment and health has acquired a lot of interest since the Intergovernmental Panel on Climate Change (IPCC) published its first report in 1990 (Gosling et al. 2009). Since then, numerous evidence-based findings have emerged showing how climate change has affected people's health (Haines et al. 2006; Michael, 2013; Michael et al. 2006). The health implications of rising temperatures, numerous infectious diseases, and modifications in rainfall patterns are some examples of these effects (Altizer et al. 2013; Islam et al. 2011). On a global scale, human-induced climate change endangers ecosystems and human health (Islam et al. 2017).

Climate change can affect health in a variety of ways, either directly or indirectly (Berry et al. 2010; Frumkin et al. 2008; Michael et al. 1997), particularly when social and environmental elements are involved. Only a few of the direct consequences of climate change include increased biological impacts of heat stress, extreme weather events such as floods and drought, and an increase in the frequency and intensity of cyclones (during particular seasons) (Balaguru et al. 2014; Singh et al. 2000; Webster et al. 2005). Changes in natural processes and services, the evolution of disease vectors, air pollution, food and water scarcity, undernutrition, eviction, and mental illness, on the other hand, may all represent indirect hazards to public health. Climate change can have an impact on human health (Costello et al. 2009; Epstein 1999; Kovats et al. 2000; Willox et al. 2015), particularly when it comes to infectious diseases (Altizer et al. 2013; Bouzid et al. 2014). Climate or weather changes influence the basic spatial and seasonal constraints of infectious disease transmission involving three critical components: an agent (or pathogen), a host (or vector), and the transmission environment. Appropriate climate and weather conditions are required for disease pathogens, vectors, and hosts to survive, reproduce, spread, and transmit (P R Epstein 2001). Many investigations have reported on the temporal and spatial influence of climate variability on the spread of infectious illnesses such as vector-borne, rodent-borne, food-borne, and water-borne diseases (Michael et al. 2006; Semenza et al. 2012; Altizer et al. 2013). Infectious diseases are mostly affected by climate change through the expansion of insect vectors and contaminated water (Bing Xu et al, 2016; Rossati et al. 2015; E K Shuman 2011). Infectious disease distribution and prevalence are expected to grow globally due to climate change, which raises the possibility of an impending social crisis (Lafferty, K. D. 2009 and Boukercherianna et al. 2020). A number of serious infectious disease outbreaks have occurred in the twenty-first century, not the least of which being the COVID-19 pandemic, which has wreaked havoc on people's lives and way of life all across the world (Baker et al. 2022).

Shifts in temperatures and weather patterns over a long period of time are referred to as climate changes. These changes might be biological, but human activity has been the main driver of climate change since the 1800s. This is mainly due to the burning of fossil fuels (including coal, oil, and gas), which produces heat-trapping gases (Rafael et al. 2021).

There are considerable gaps in understanding concerning the impact of climate change on health, livelihood, and well-being in lower middle-income nations like Bangladesh, which is one of the world's most climate sensitive countries. While Bangladesh has some isolated evidence linking climate change to greater rates of death and morbidity from certain illnesses, there is no thorough

evaluation of the existing data and no agreement on the effects of climate change getting emerging infectious diseases among human health. There are gray literature outputs, but they cannot be published in peer-reviewed journals due to a lack of local experts.

Bangladesh, a country in South Asia with a population of around 160 million people, is one of the countries with the densest populations in the world. The majority of the country is low-lying, and floodplains cover 80% of it (Milliman et al. 1989; Masrur et al. 2022; Islam 2008). The monsoon season plays a crucial role in determining Bangladesh's hot, humid weather. Pre-monsoon (March to May), monsoon (June to early October), post-monsoon (December to February), and late-monsoon (October to November) are the four distinct seasons (Islam 2008). Because of its geographic location, Bangladesh is one of the nations that is most vulnerable to disasters. The weather has a significant impact on health. Climate restricts the variety of infectious diseases, whereas weather affects the timing and intensity of outbreaks (Enamul et al. 2016).

Infectious diseases are illnesses caused by harmful agents which get into our body (Katherine et al. 2009). Infectious illness prevalence, socioeconomic factors, and climate change all have a long-term co-integrating relationship. In Bangladesh, the prevalence of infectious diseases is significantly impacted by climate change (Meghnath et al. 2021 and Jonathan et al. 2005). Comparatively to industrialized regions, Bangladesh and other developing nations have been disproportionately impacted by climate change (Mohammed et al. 2021). Infectious diseases are spreading, and together with changes in plant ecosystems and the melting of alpine glaciers, the ranges of infectious disorders and their vectors are changing northward (Mimikou et al. 2000; Epstein et al. 2001 and Bitam et al. 2010). Extreme weather conditions can also lead to "clusters" of water-, rodent-, and insect-borne illnesses, food, water, and vector-borne infections (Enamul et al. 2016; Anwar et al. 2019; Epstein et al. 2001). Bangladesh has much fewer greenhouse gas emissions than many other industrialized countries (Saleemul at al. 2001), but the country faces a grave threat from climate change to its people's health (Enamul et al. 2016). Following the natural disaster, the incidence of diarrhea, skin conditions, dengue fever, hepatitis (jaundice), and other infectious disorders has increased (Lemonick et al. 2011 and Russell et al. 2014). The majority of health professionals, service providers, and local residents in coastal areas are more knowledgeable about the effects of climate change on health (Smith et al. 2016), but they are less knowledgeable about the precautions that should be taken (Russell et al. 2014).

The priority should be on minimizing the effects of climate change, particularly any potential repercussions on the prevalence of infectious diseases globally (Hossain et al. 2014). Even though the world is significantly warmer than it was a century ago, there is little evidence that infectious diseases have already become more common because of climate change (Hanna et al. 2016). More recent models indicate range shifts in disease distributions, with no net expansion in area, in contrast to earlier predictions that predicted the global range of infectious diseases will drastically increase in the future.

In Bangladesh, the majority of climate research is concentrated on agriculture, hydrological, and other environmental issues, highlighting the glaring dearth of health specialists in the field. Furthermore, a detailed study of the incomplete data that is now accessible has not yet been carried out. According to the author's best judgment, there is no concrete proof that the impact of climate change on emerging infectious diseases might be evident in Bangladesh. Making informed judgments on health policy in relation to climate change is difficult due to a lack of transdisciplinary research and evidence. By compiling the data that is easily available and under our control, the current review aims to close the information gap. In this review, we investigate

the evidence for changes in infectious disease incidence, distribution, localized outbreaks, and the potential for tropical vector species to establish in Bangladesh because of climatic changes. We anticipate that this analysis will contribute to the existing discussion involving the debate about
climate change and serve as a resource for stakeholders from a variety of disciplinary backgrounds.

Methodology

Through inquiry, it has been revealed how much Bangladesh's climate is changing and how it is affecting people's health (Enamul et al. 2016 and Epstein et al. 2001). Infectious disease is influenced by a variety of variables, some of which may even be more significant than climate-related factors (Lafferty K. D. 2009). So, the relationship between climate change and infectious diseases in Bangladesh requires rigorous examination and investigation.

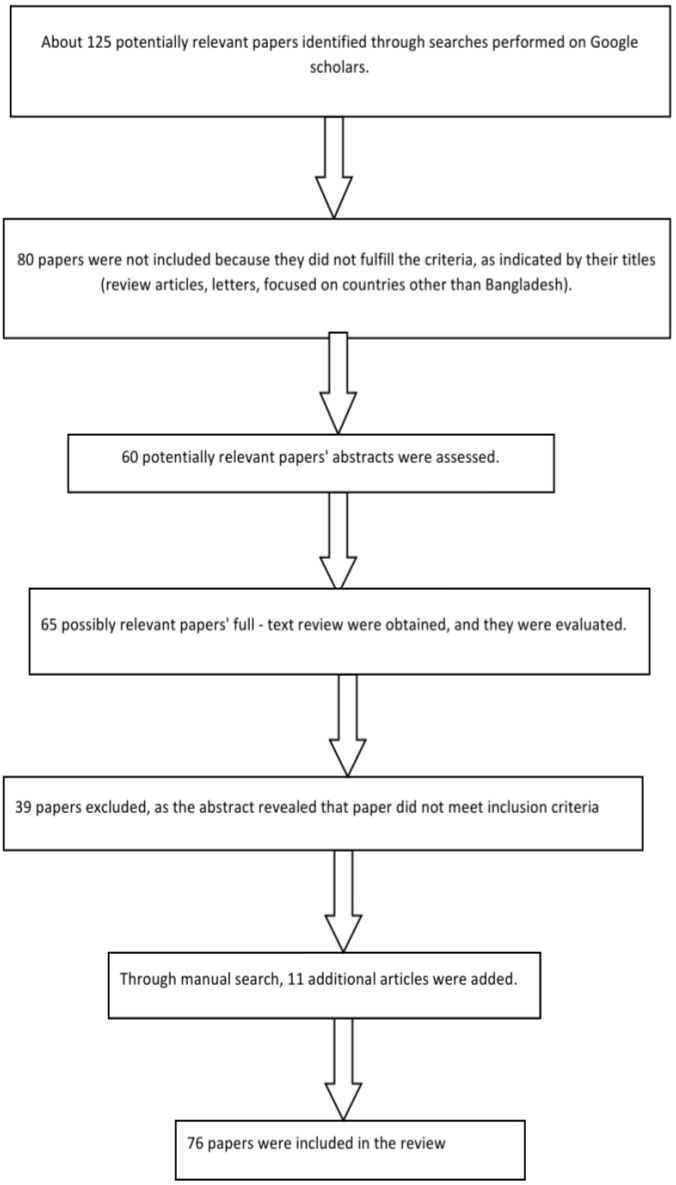

Figure 1: Flow chart of combining papers by searching for our review paper.

In this review, the effects of climate change on Bangladeshi citizens' health were evaluated. Multiple databases were picked to discover relevant articles. We got information about climate change, infectious diseases, and their effects on health from those periodicals. The potential effects of the connection between human infectious diseases and climate change are discussed here. In our research, we also explore how climate change is altering the types of infectious diseases and their vectors, greenhouse gas emissions, and how much Bangladesh's climate is changing and how it is affecting the health of its citizens. Finally, we combined all types of information about the effects of climate change on human health (Figure 1). But in this topic, we've tried to give some original material on the potential effects of extreme weather on humans' infectious diseases of Bangladesh. In the future, we'll work on more connected projects that are associated with infectious diseases and adverse climate changes. The number of papers published each year that match their search criteria is shown by the blue bars. The total number of papers is displayed on an orange line (Figure 2).

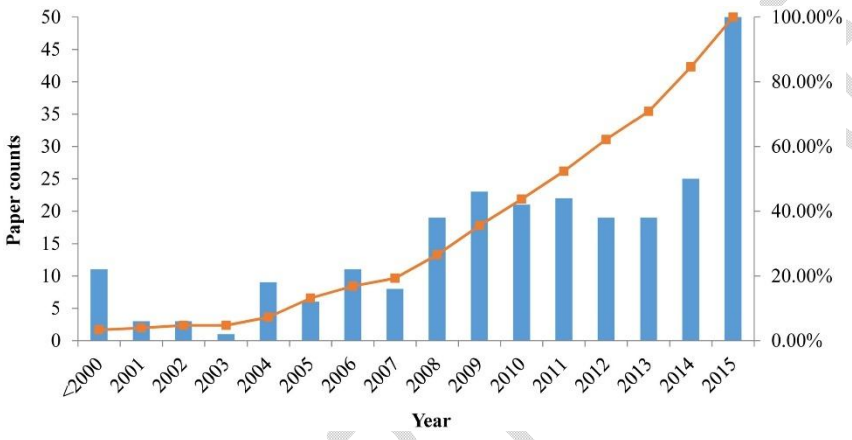

Figure 2: Growing awareness of the links between climate change and health (Lu Liang et al., 2017).

Vector borne disease:

Climate change causes extreme weather patterns, which also affect vector-borne diseases (Githeko et al. 2000 and Campbell et al. 2015). In order to determine parasite activity levels and illness risk, it is critical to understand the relationship between climatic variables and vector-borne diseases (Rahman M. J. 2014). The likelihood of dengue fever, Chikungunya, and Zika virus will increase as global temperatures and weather patterns change due to climate change (Kaffenberger et al. 2017 and Asad et al. 2018). Warmer temperatures have the potential to broaden the geographic range of habitats where vectors, such as mosquitos and ticks, can live and lay eggs (Jan et al. 2022).

Mosquito borne disease:

Climate is one of the factors influencing the growth of malaria cases (Ubydul et al. 2010). Climate change is responsible for 2% of all malaria cases worldwide (Hossain et al. 2014).

Arboviral Diseases:

Aedes aegypti, the leading mosquito vector of arboviral diseases such as dengue, chikungunya, yellow fever, and Zika, threatens about half of the world's population. The rise in global temperatures is partially responsible for this increase (Troncoso, 2016). As temperatures approach the predicted thermal optimum, Zika may spread further north with longer seasons (Jan et al. 2022).

Tick-Borne Diseases:

The spread of Lyme disease, Rocky Mountain spotted fever, and leishmaniasis is aided by high temperatures, the creation of tick populations, an increase in their range, and recent geographic expansion (Jan et al. 2022).

Food-Borne Diseases:

The number of viruses that propagate depends significantly on the environment. The geographic distribution, variety, levels, and seasonality of the pathogen in the natural and agricultural environment may therefore change because of changing environmental factors, such as changes in precipitation temperature (Chantel et al. 2011). In the end, this affects the quantity of pathogens in food, and climate change will bring about a rise in temperature and precipitation, both of which affect the spread of infectious diseases through contaminated food and water (Hales et al. 2003 and CDC, 2009). Salmonella is sensitive to the climate and thrives in a small temperature range with pronounced seasonality (Cherrie et al. 2018 and Arora et al. 2015). However, it is anticipated that the threat to food safety posed by both recent and emerging food-borne illnesses will increase as ambient temperature rises and severe weather events become more frequent (Misiou et al. 2021).

Water-Borne Diseases:

Drinking contaminated water or coming into contact with it can spread waterborne infections (Alan et al., 2022). Water shortages and drought can also give rise to cascading risks and cause diarrheal diseases, although this association has been documented inconsistently (Jan et al. 2022 and Thorseth et al. 2021). Water-borne outbreaks can occur because of climate variability and change followed by secondary events that are causally connected (Priya et al. 2013 and Jan et al. 2022). Vibrio cholerae has been linked to several climatic factors, poor WASH conditions, and areas where cholera has already been introduced to the population (Cyril et al. 2019). High rainfall might increase the chance that treated or untreated water will get contaminated by wastewater (person-to-environment transmission) (Jan et al. 2022). Leptospirosis outbreaks can be brought on by contaminated floodwater or drinking water, highlighting the interplay between climate risk, societal vulnerability, and population exposure in the development of cascade risk pathways for leptospirosis (Jonathan et al. 2020). Respiratory infections frequently have high seasonality, with a wintertime peak in frequency. This is partly due to improved pathogen survival, indoor congestion, and greater host vulnerability (K Collins 2005). For instance, temperature and humidity have an impact on influenza incidence in temperate regions around the world (Chun et al. 2020).

Rodent-borne diseases:

Some human diseases are carried by rodents (James N Mills 1999 & Emily et al. 2008). Weather has an impact on rodent numbers (Aleksandra et al. 2015). Flooding is linked to some rodent-

borne diseases, such as plague, Hantavirus, and Lyme disease, while the others are linked to rats and ticks (Hales et al. 2003). Rodent population density and weather-sensitive behavior frequently have an impact on the frequency of transmission of these diseases (Gubler et al. 2001 & M.J. Rahman, 2014).

Plague:

The Yersinia pestis bacteria, which causes plague, is spread by fleas that feed on black rats (Rattus rattus) (Tollenaere et al. 2010). Although rodent populations perform well in warmer temperatures, unfavorable conditions like heat waves may force them indoors in search of water, increasing their contact with humans (*Semenza et al. 2009).*

Hantavirus Infections:

Weather can affect hantavirus infection; for example, increased grass seed production following a period of heavy precipitation has been linked to an increase in the number of deer mice, which resulted in an outbreak in the Four Corners region of the United States (New Mexico) (*Semenza et al. 2009).*

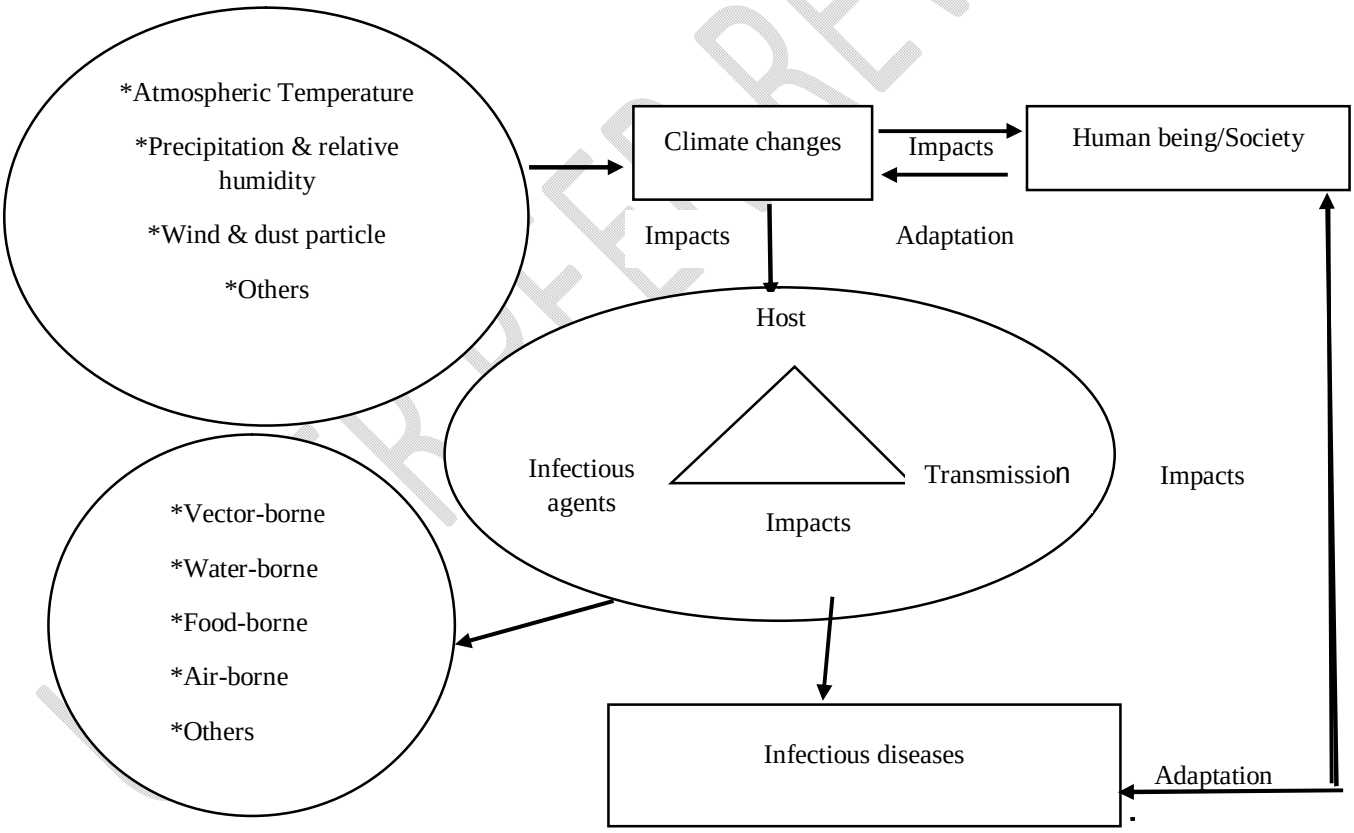

Figure 3: Climate change, human infectious diseases, and human society (Wu, et al. 2015).

Conclusion and policy implications:

Climate change may have opposing effects on pathogen, vector, and ultimately disease outcome at distinct regional and temporal dimensions (Paterson et al. 2010; Robert W Sutherst, 2004). The complexity of how various changes interact and affect any one of the three characteristics of human infectious illnesses may be a factor in our inability to fully comprehend how climate change will affect human health as a whole (Collins et al. 2003 and Janet et al. 2011). New challenges to human infectious disease health brought on by climate change will limit some diseases' ability to spread while promoting others (Johanna et al. 2015; Kevin D Lafferty, 2009 and Hilary et al. 2017). One of the best strategies for human society is to lessen vulnerability by implementing adaptation measures (Barry et al., 2006). Advancements in science and society are required in a number of areas to choose the optimum adaptation approach (Tebaldi et al. 2008). People are not merely passive beneficiaries of climate change's negative health effects (Xiaoxu et al. 2016). By taking proactive adaptation strategies, we may significantly and actively contribute to reducing and controlling the harmful effects of climate change on human health (Shakeel et al. 2009). It is critical to first predict how localized climate change may affect the spread of infectious illnesses (Anthony et al. 2011). The country will be better able to track the progression of diseases that are influenced by the climate and predict disease outbreaks (Xiaoxu et al. 2016 and Ali et al. 2020). Second, even with the same level of climate change, some locations and population groups are more vulnerable to the increasing risks because they are underequipped and unable to cope with the demands and challenges (Islam et al. 2017). To reduce their susceptibility to health threats brought on by climate change, industrialized countries and competent societies should cooperate with developing countries and less capable societies (Roman et al. 2010). Area-specific treatments guided by local-level planning of the low-income vulnerable communities are required to address the prevention and control of climate-sensitive diseases (Xiaoxu et al. 2016 and Kabir et al. 2016). Improve health systems to avoid and limit the spread of infectious diseases as well as other recently discovered or rediscovered climate-sensitive diseases (Xiaoxu et al. 2016 and Ali et al. 2020). Third, by taking the appropriate adaptation strategies, human vulnerability to the evolving risks for infectious diseases may be modified (Jolyon et al. 2015).

Next steps or Challenges:

Early warning systems built on these estimates have been successful in assisting societies in taking preventative measures to limit or avert potential health repercussions (Reid Basher, 2006). Increase response to mental health issues through raising awareness, enhancing evaluation processes, and supporting methods for addressing deficiencies, such as self-help groups (Xiaoxu et al. 2016 and Ali et al. 2020). To lower OOP (Out-Of-Pocket expense) payments for climate victims through alternative health care finance, government actions, strong public-private advocacy, and international partnerships are required (David et al. 2019). In the end, climate change affects health, so community-based public health care facilities should be ready to be used to their fullest capacity (Van et al., 2008). Studies including child-centered and school-based interventions could be investigated to lower seasonal childhood pneumonia, malnutrition, and diarrhea (Claire et al. 2019).

Based on the results of this survey, future cohort studies could assist decision-makers and public health experts in lowering the health costs that climate change is imposing on Bangladesh and

other developing countries (Kabir et al., 2016). By implementing the measures to control diarrheal illnesses, a consistent supply of clean water, and sanitary facilities, Bangladesh, particularly in vulnerable places, will be able to control other water-borne illnesses including typhoid and hepatitis A (Enamul et al. 2016). Reforestation will reduce the consequences of climate change by halting soil erosion and improving air quality (Smith et al. 2016). Health must come first in any adaptation plans for climate change. Significant and ongoing study is also necessary to understand how climate change and health are related. If quick action is not taken to reduce and adapt to climate change, Bangladesh will pay a heavy price in terms of productivity and human life (Enamul et al. 2016).

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